[012] The support rods with small feature sizes are desirable in order not to perturb the optical mode propagating through the suspended oxide waveguide. However, this imposes a design trade-off as support rods with wider feature size improve mechanical support against shakes, vibrations, and shear effect.

[013] This is especially important in densely integrated multi-input/output coupling schemes, e.g., a photonic integrated circuit where a closely spaced row of suspended edge couplers is used as an optical phased array emitter/receiver block. In such use cases, the suspended edge couplers with oxide support rods of small feature size become more susceptible to waveguide collapse and/or breakage as support rod width can be further diminished due to the aggregate effect of isotropic silicon etch of adjacent waveguides.

[014] FIGs. 1A, 1B and 1C illustrate a conventional suspended edge coupler 100 with oxide support rods in rectangular footprint.

[015] The conventional suspended edge coupler 100 includes a suspended oxide waveguide 102, rows of isolation trenches 104 on both sides of the suspended oxide waveguide 102, a row of oxide support rods having rectangular footprint 106 and arranged on both sides of the suspended oxide waveguide 102 to provide mechanical support, a nano-taper 108 to facilitate adiabatic coupling of light from the suspended oxide waveguide 102 into a silicon waveguide 110.

[016] While many existing approaches focus on optimizing coupling performance, very few approaches are concerned about mechanical reliability or rigidity of the suspended edge couplers.

SUMMARY

[017] According to the present disclosure, there is provided an edge coupler that comprises:

a suspended waveguide having a longitudinal direction and a lateral direction, the waveguide arranged between two longitudinal rows of periodic isolation trenches;

an outer cladding;

a plurality of lateral support rods arranged between the isolation trenches and interconnecting the waveguide and the outer cladding;

a silicon substrate having a cavity in fluid communication with the isolation trenches, wherein the waveguide and the support rods are suspended over the cavity, wherein the outer cladding is supported by the substrate; and

an inverse taper of a second waveguide which is embedded in the suspended waveguide,

wherein each support rod includes a footprint having a first edge width interfacing the waveguide, and a second edge width interfacing the cladding, wherein the second edge width is larger than the first edge width.

[017A] In an aspect of the present disclosure, there is provided an edge coupler including a suspended waveguide having a longitudinal direction and a lateral direction, the suspended waveguide arranged between two longitudinal rows of periodic isolation trenches;

an outer cladding;

a plurality of lateral support rods arranged between the isolation trenches and interconnecting the suspended waveguide and the outer cladding;

a silicon substrate having a cavity in fluid communication with the isolation trenches, wherein the suspended waveguide and the support rods are suspended over the cavity, wherein the outer cladding is supported by the substrate; and

an inverse taper of a second waveguide which is embedded in the suspended waveguide,

wherein each support rod includes a footprint having a first edge width interfacing the suspended waveguide, and a second edge width interfacing the outer cladding, wherein the second edge width is larger than the first edge width, and wherein the footprint of each support rod includes a third edge width and a fourth edge width interfacing adjacent ones of the isolation trenches, wherein the third edge width and/or the fourth edge width include an arc of a circle, an ellipse, a parabola, or a hyperbola.

[018] According to the present disclosure, there is provided a method for fabricating an edge coupler, the method comprising:

forming a top cladding on a silicon-on-insulator (SOI) structure which includes a silicon layer which is formed on a buried oxide (BOX) layer which is formed on a silicon substrate;

without etching the silicon substrate, pattern etching the top cladding and the SOI structure with two longitudinal rows of periodic isolation trenches to define an inner cladding between the two longitudinal rows of periodic isolation trenches, an outer cladding separated from the inner cladding by one of the two longitudinal rows of periodic isolation trenches, and lateral support rods interconnecting the inner cladding and the outer cladding;

isotropic etching the silicon substrate to cause suspension of the inner cladding to provide a suspended waveguide;

wherein each support rod includes a footprint having a first edge width interfacing the suspended waveguide, and a second edge width interfacing the outer cladding, wherein the second edge width is larger than the first edge width, and wherein the first waveguide includes an inverse taper of a second waveguide.

[018A] In another aspect of the present disclosure, there is provided a method for fabricating an edge coupler, the method comprising:

forming a top cladding on a silicon-on-insulator (SOI) structure which includes a silicon layer which is formed on a buried oxide (BOX) layer which is formed on a silicon substrate;

without etching the silicon substrate, pattern etching the top cladding and the SOI structure with two longitudinal rows of periodic isolation trenches to define an inner cladding between the two longitudinal rows of periodic isolation trenches, an outer cladding separated from the inner cladding by one of the two longitudinal rows of periodic isolation trenches, and lateral support rods interconnecting the inner cladding and the outer cladding;

isotropic etching the silicon substrate to cause suspension of the inner cladding to provide a suspended waveguide;

wherein each support rod includes a footprint having a first edge width interfacing the suspended waveguide, and a second edge width interfacing the outer cladding, wherein the second edge width is larger than the first edge width, and wherein the suspended waveguide includes an inverse taper of a second waveguide, and

wherein the footprint of each support rod includes a third edge width and a fourth edge width interfacing adjacent ones of the isolation trenches, wherein the third edge width and/or the fourth edge width include an arc of a circle, an ellipse, a parabola, or a hyperbola.

CLAIMS

1. An edge coupler comprising:

a suspended waveguide having a longitudinal direction and a lateral direction, the suspended waveguide arranged between two longitudinal rows of periodic isolation trenches;

an outer cladding;

a plurality of lateral support rods arranged between the isolation trenches and interconnecting the suspended waveguide and the outer cladding;

a silicon substrate having a cavity in fluid communication with the isolation trenches, wherein the suspended waveguide and the support rods are suspended over the cavity, wherein the outer cladding is supported by the substrate; and

an inverse taper of a second waveguide which is embedded in the suspended waveguide,

wherein each support rod includes a footprint having a first edge width interfacing the suspended waveguide, and a second edge width interfacing the outer cladding, wherein the second edge width is larger than the first edge width, and

wherein the footprint of each support rod includes a third edge width and a fourth edge width interfacing adjacent ones of the isolation trenches, wherein the third edge width and/or the fourth edge width include an arc of a circle, an ellipse, a parabola, or a hyperbola.

2. The edge coupler of claim 1, wherein the third edge width and the fourth edge width are asymmetric relative to each other.

3. The edge coupler of claim 1 or claim 2, wherein the suspended waveguide includes a lateral dimension which tapers along the longitudinal direction.

4. The edge coupler of any one of claim 1 to claim 3, wherein the isolation trenches include air.

5. A method for fabricating an edge coupler, the method comprising:

forming a top cladding on a silicon-on-insulator (SOI) structure which includes a silicon layer which is formed on a buried oxide (BOX) layer which is formed on a silicon substrate;

without etching the silicon substrate, pattern etching the top cladding and the SOI structure with two longitudinal rows of periodic isolation trenches to define an inner cladding between the two longitudinal rows of periodic isolation trenches, an outer cladding separated from the inner cladding by one of the two longitudinal rows of periodic isolation trenches, and lateral support rods interconnecting the inner cladding and the outer cladding;

isotropic etching the silicon substrate to cause suspension of the inner cladding to provide a suspended waveguide;

wherein each support rod includes a footprint having a first edge width interfacing the suspended waveguide, and a second edge width interfacing the outer cladding, wherein the second edge width is larger than the first edge width, and

wherein the suspended waveguide includes an inverse taper of a second waveguide, and

wherein the footprint of each support rod includes a third edge width and a fourth edge width interfacing adjacent ones of the isolation trenches, wherein the third edge width and/or the fourth edge width include an arc of a circle, an ellipse, a parabola, or a hyperbola.

6. The method of claim 5, wherein the third edge width and the fourth edge width are asymmetric relative to each other.

7. The method of claim 5 or claim 6, wherein the suspended waveguide includes a lateral dimension which tapers along the longitudinal direction.

8. The method of any one of claim 5 to claim 7, wherein the isolation trenches include air.